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Farmer knowledge on biodiversity conservation by shade trees in cocoa farms of Western-North Ghana

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Abstract

This paper sought to examine farmers' knowledge about how shade trees conserve biodiversity in cocoa farms in 5 randomly selected communities in the Bia-West District in the Western-North region of Ghana. A total of 65 active cocoa farmers with outstanding experience and practice in cocoa cultivation were interviewed using open-ended questions during key informant interviews and Focused Group Discussions to collect detailed knowledge on how shade trees conserve biodiversity in cocoa farms. The findings show that farmers are knowledgeable regarding how shade trees conserve biodiversity in cocoa farms. Provision of habitat and safety, food, temperature and humidity control as well as soil protection were the main knowledge held by farmers on how shade trees conserve biodiversity. However biodiversity conserved by shade trees are either desirable or undesirable based on whether the species conserved can served as food or non-food; wild nor non-wild; and favorable or unfavorable for cocoa production. Among others, it is recommended that farmer education on benefits of shade tree cultivation in cocoa farms should start with and incorporate farmers' knowledge as this can stimulate farmer interest in such education activities.

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Introduction

Traditionally, cocoa is famous as shade-loving crop and so develops well under the vestige of taller trees from thinned forest (Gockowski *et al.,* 2010). Traditional cocoa farms grown under structurally and floristically diverse canopy of shade trees provide habitat for high diversity of flora and fauna (Zapfack *et al.*, 2002). Since shaded cocoa farms enriched with non-timber products maintain essential characteristics of natural forests, they create a new landscape element that conserve biodiversity (Bisseleua *et al.,* 2009; Rice & Greenberg, 2000; Leakey, 2001; Schroth *et al.,* 2004). In particular, cocoa agroforests can create forest-like habitats, which harbour tropical biodiversity in rapidly degrading landscapes (Greenberg *et al.,* 2000), while providing an economic crop for small-holder farmers, and serving as faunal refuges (Griffith, 2000).

However, farmers are increasingly recognized as playing a critical role as ecosystem managers, when it comes to the derivation of the biodiversity conservation benefits of shaded cocoa farms. The provision of ecosystem services from agroforestry clearly depends on their management decisions. Their management decisions, in turn, depend on their knowledge of both the ecosystem provided by their plantations, in particular, by the trees they contain, and the trade-offs between shade trees and biodiversity conservation in their specific context. Farmers are shown to have detailed knowledge regarding ecological, biological and economic services that their agroforestry systems provide as well as on the interactions between trees and productivity (Cerdan *et al.*, 2012).

In West Africa, farmers have been found to have shown diverse local knowledge on shade tree species and their interactions with cocoa (Asare, 2005). Graefe *et al.,* (2017) evaluated farmers' knowledge of shade trees in different ecological zones. Farmers in Ghana have been found to possess very good knowledge of trees and their importance, or otherwise, in the cocoa landscape (Osei-Bonsu *et al.,* 2003; Anglaaere, 2011). This local knowledge has been noted to be location specific and is dependent on both the importance of the particular species to the farmer and its interaction with the cocoa trees on farm. Hence, some researchers have suggested that this knowledge should be used to complement scientific knowledge in order to integrate farmers' perspectives into the research and development frameworks (Dawoe *et al.,* 2012). Farmers in Anglaare *eta al.,* 2011), identified a number of trees found on farms as well as their respective characteristics, uses and their ecological interactions with cocoa. Trees were classified by farmers as either good or bad on the basis of their compatibility with cocoa as neighbour trees. Coffee farmers have identified the usefulness of tree species present in their farm in regards to small mammal and bird diversity conservation and the type of resource each tree provides. Cerdan *et al.,* 2012) report that farmers were knowledgeable on bird and mammal behaviour in relation to the trees in their farms, such as feeding patterns and habitat preferences for nesting or protection.

However, scanty information exists regarding cocoa farmers' local knowledge of how shade trees affect biodiversity conservation, which local knowledge has the potential to influence shade tree species cultivation and management decisions of farmers. Few studies have documented farmers' knowledge about agroforestry and specifically shade trees and little has been reported about their knowledge on the interactions between trees and biodiversity conservation in cocoa agroforestry. Unlike Costa Rica (Cerdán *et al.,* 2012), exploration of farmer knowledge of shade trees have excluded how shade trees affect biodiversity conservation.

In view of the foregoing, this study set out to achieve the following objectives;

a. Examine farmers' knowledge on how shade trees conserve biodiversity in cocoa farms

b. To examine famers knowledge on what biodiversity are conserved by shade trees in cocoa farms

The effort of this study to examine farmers' knowledge of shade tree on biodiversity conservation has the potential to provide a repository of local

knowledge of farmers of the effects of shade trees on biodiversity conservation. It is therefore expected that when this local knowledge base is combined with knowledge of scientists and extension workers, a richer understanding of the role of plant species in cocoa production systems would emerge. This study therefore anticipates that communication amongst farmers, extension staff and scientists would be improved by a greater mutual understanding of each other's knowledge. It is expected that the results of this study will complement other research works in Ghana (Anglaare *et al.,* 2011) that examine local knowledge of trees and effects on microclimatic services in cocoa farms. However this study has the potential to identify shade trees that farmers perceive to distinguishably affect biodiversity in cocoa landscapes.

Materials and methods

Study Area

This study was carried out in Bia West District in the Western North Region of Ghana. The Bia West District shares boundaries with the Bia East District Assembly to the north east, La Cote d'Ivoire to the west, and Juaboso District to the south east. The district capital, Essam-Debiso is located 420km to the north-west of Takoradi and 250km to Kumasi. The district has a total surface area of 1,287,265 square kilometres (GSS, 2014). The total population of the District of Bia West in 2010 was approximately 103,539 people made up of 53,219 (51.4%) males and 50,320 (48.6%) females (GSS, 2014).

The Bia West District forms part of the wet semi-equatorial climatic zone. It has a mean annual rainfall figures ranges from 1,250mm to 2,000mm and suitable for the growing of various crops particularly both cash and food crops (GSS, 2014). The district typically experiences two main wet and dry seasons. The wet season is between April and October and the dry season is between November and March. The heavy and prolonged rains however aggravate the black pod disease that attacks cocoa (GSS, 2014).

The District's vegetation is of the moist semi-deciduous (equatorial rain forest) type. The district has a rich diversity of fauna and flora. There are also two forest reserves in the district namely Bia North and Bia South Forest Reserves (GSS, 2014). The former is a protected reserve while the latter is a productive reserve where timber harvesting is done. Occasional bushfires, poaching and encroachment of land are threatening the existence of the reserves. In addition, high exploitation of timber for logs and lumber by both registered timber firms and illegal chainsaw operators has contributed significantly to deforestation in the district (GSS, 2014).

Greater proportion of the available land has been used for cocoa cultivation and a sizeable space of the land is under forest reservation. The Ghana Statistical Service (2014), found that agriculture is the main economic activity of the people of the district, with cocoa being the dominant crop in the District. Agriculture employs about 74.7% of the total labour force. On average, farmers in the area cultivate 2-4 cocoa farms (Hainmueller *et al.*, 2011), with the average farm covering approximately 2.7 acres (1.2 ha) (Hainmueller *et al.*, 2011).

Sample and Sampling Technique

Due to time and resource constraints, five (5) cocoa growing communities out of total of 36 Mondelez International Cocoa-life communities in the Bia West district were randomly sampled. These 36 Cocoa-life communities are scattered across the district. As a result, the whole study area was grouped into five (5) main clusters namely the North, South, East and West and Central clusters. In each of these clusters, the names of Cocoa-life farming communities were written on pieces of paper. The researcher then blindly selected one (1) out of these pieces of paper. The name of the community on the randomly selected paper was therefore included in the study.

Purposive sampling technique was used to select key cocoa farmers to collect detailed knowledge from them on how shade trees conserve biodiversity in cocoa farms. In each of the five (5) randomly selected communities, five (5) of the executives of the Mondelez International Cocoa-life Farmer Society

were purposively selected since they are active cocoa farmers with outstanding experience and practice in cocoa cultivation.

In addition, focused group discussions with cocoa farmers selected from the Mondelez Cocoa-life Farmer Society in each of the selected communities were carried out. In each of these five (5) communities, eight (8) member focused groups made up of both male and female cocoa farmers were identified and interviewed.

Data Collection

The method of data collection on farmer's knowledge in this study relied more on the use of Participatory Rural Appraisal Techniques (PRA) including key informant and group discussions to gather primary data from the study respondents. A checklist of informal interviews made up of open-ended questions were prepared, to ensure that important issues were not left out during focused group discussions and key informant interviews. Farmers were interviewed about shade trees and how shade trees conserve biodiversity in cocoa farms. Few farm visits and transect walks were carried out on the farms with key informants and FGDs with farmers randomly to triangulate and validate information during interviews and focused group discussions. Responses during key informant interviews and focused group discussions were audio recorded in order to ensure that important information were not missed. However, in addition to the audio recording, interviewers took field notes of the responses of respondents during focused group discussion as well as key informant interviews.

Data analysis

Audio records of farmers' responses were translated into English. Translations were then cross-checked with hand written field notes to ensure validity, reliability, and quality control. The transcripts and interview notes were read several times, so that common categories, and themes and topics were extrapolated from the open-ended responses provided by the key informants and focused group discussant. Afterwards, the identified themes and categories were analyzed to identify differences and patterns within the responses which also aided in organizing and describing the data in rich detail (Braun & Clarke, 2006). The identified themes and categories from the normative views of the respondents were analyzed and presented in the form of frequencies and tables.

Results and discussions

Socio-Demographic Characteristics of Respondents

A total of 65 respondents were involved in the in-depth interview on farmer's local knowledge of shade tree on cocoa farms and biodiversity conservation. The 65 respondents comprised 25 key informants (leaders of cocoa farmer cooperatives) and 40 focused group discussants in five communities namely Asuopri, Yawmatwa, Kojoaba, Biano, and Nyame Nnae. In respect of the key informants, 8 were females while the remaining 17 were males indicating male dominance in leading cocoa farmer groups. Eighteen (18) of all focused group discussants were females while the remaining 22 were males. Majority of the respondents had basic education while just about 2% have had up to middle school education.

All the key informants were native of the study area and owners of the cocoa farms. However, respondents at the focused group discussions comprised 17 migrant farmers who were also sharecroppers. All the farmer respondents are conventional farmers, applying varied inputs in the cultivation of cocoa. Table 1 provides a summary of the demographic characteristics of the respondents selected.

How shade trees conserve biodiversity in cocoa farms

The study participants intimated four (4) main ways used by shade trees to conserve biodiversity in cocoa farms namely; provision of food, safety and habitat, temperature and humidity control and soil protection. This was derived from a total of 326 responses gleaned from the participants' responses regarding how shade trees conserve biodiversity in cocoa farms. Fig. 1 below shows the frequencies of this knowledge of farmers.

Table 1. Demographic and Farm Characteristics of Respondents.

Variable	Category	Freq.	Percentage (%)
Gender	Male	39	60
	Female	26	40
Educational Level	No formal schooling	29	45.1
	Basic (primary & JHS)	33	49.6
	Secondary	2	3.3
	Tertiary	1	2
Residential Status	Native	48	73.8
	Migrant	17	26.2
Type of land tenure	Owner	29	44.6
	Sharecropper	17	26.2
	Family	11	16.9
	Abunu	8	12.3
Total		65	100

One-hundred and fourteen (114) of all the farmers' responses representing about 35% were about safety and habitat as a mechanism used by shade trees to conserve biodiversity in cocoa farms (Fig. 1). Farmers indicated that shade trees conserve biodiversity by serving as place of perching, hiding, nesting, and holes for other mammals (see exhibit 1). Yet, some shade trees looks as destructive (*Colo nitida*), as attracting diseases like mistletoe etc. Additional species are highly cherished, because it provides fruits and timber as supplementary income (*Persea Americana*). This observation affirms Annani's, 2012) statement that some timber trees like, *Ceiba pentandra* (Onyina), *Terminalia superba* (Ofram), *Pycnanthus angolensis* (Otie) and *Cola gigantean* (Watapuo) serve as hiding places for rodents such as squirrels which causes destruction to cocoa pods.

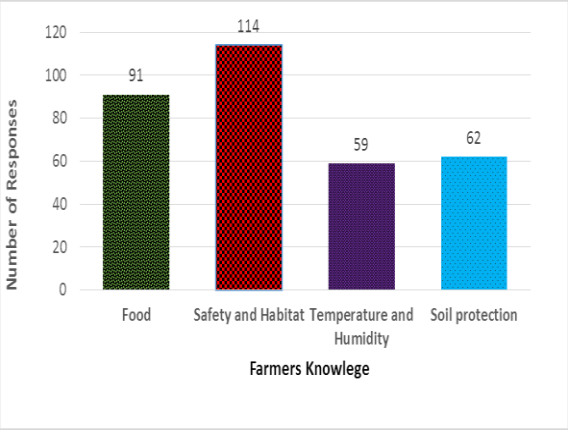

Fig. 1. How shade trees conserve biodiversity in cocoa farms according to farmers' knowledge.

Provision of food was another means identified by farmers as a way through which shade trees in cocoa farms conserve biodiversity. Ninety-one of all the responses, representing about 28% were about food provision as a mechanism of biodiversity conservation by shade trees in cocoa farms. Farmers indicated that shade trees provide fruits, water, ripped foods for other mammals which help to preserve and keep these mammals alive.

Temperature and humidity function of shade trees regarding biodiversity conservation was the least mentioned among the responses from the interview. Fifty-nine (59) of the total responses from farmers representing about 18% indicated that farmers hold the knowledge that shade trees conserve biodiversity by regulating temperature and humidity. Farmers indicated that some shade trees draw water while others regulate sunlight penetration into the cocoa farm which in turn helps to regulate the temperature that can be tolerated by water bodies and other mammals. Anglaare *et al.,* 2011) found that farmers have the understanding that shade trees through their plant density and architecture of the aerial parts of the shade influence the amount of solar radiation the understorey, humidity and circulation. Farmers recognize that while certain tree species were capable of bringing up water from deep down the soil to keep the soil surface beneath them moist and cool, there were others that have the characteristics of making the soil beneath them dry and hard (Anglaare *et al.,* 2011). In a study conducted by Smith Dumont *et al.*, 2014) in Ivory Coast the reduction of heat stress was the most stated benefit (mentioned by 70% of farmers) shade trees.

Biodiversity conserved by shade trees in cocoa farms

Biodiversity conserved by shade trees in cocoa farms according to farmers' knowledge was grouped into desirable and undesirable biodiversity. Desirable biodiversity conserved by shade trees were further grouped into food, favorability for cocoa production and non-wild biodiversity while undesirable biodiversity included biodiversity that are non-food, unfavourable for cocoa production and wildness.

This classification by this study's participants is similar to what Anglaare *et al.* (2011), found that farmers used tree respective characteristics, uses and ecological interaction to classify trees as either good or bad on the basis of their compatibility with cocoa as neighbour trees. Farmers used a fresh/hot classification for trees that involves many different attributes and overlaps with classifications relating to soil and water. Trees that were classified as 'fresh' were thought to be good for water conservation, whereas 'hot' trees were strongly related to low water conservation (Cerdán, 2012).

A total of 335 responses were identified which were categorized into desirable and undesirable biodiversity conserved by shade trees in cocoa agroforests. Within the desirable classification, species conserved by shade trees that are favourable for cocoa production recorded the highest response. Farmers intimated that certain species conserved by shade trees are favourable for production and therefore they are desirable species conserved by shade trees. For example, farmers cited that *Spathodea companulata* (Akuakua-ninsuo) conserve soil by drawing water which is good for cocoa production. Also farmers cited that *Oecophylla smaragdina* (Nhowia) help drive away unwanted insects and reptiles like snakes. Desirable species conserved by shade trees because they provide source of food or meat was recorded 95 times representing about 28% of all responses. For instance, farmers cited that shade trees may serve as place of residents for rats which can be hunted for meat.

With respect to undesirable species conserved by shade trees, species that are unfavourable for cocoa production recorded the highest. One-hundred and twenty-five (125) of responses representing approximately 37% were about undesirable species conserved by shade trees which are unfavorable for cocoa cultivation. Farmers indicated that certain species conserved by shade trees are not good for cocoa cultivation. For example farmers cited that shade trees may provide place for hiding rodents like squirrels that eat the cocoa pods and beans. Undesirable species in cocoa farm conserved by shade trees because such conserved species are wildlife was also frequently mentioned by farmers (118 responses representing about 35%). For instance, farmers cited that snakes may be conserved by plantain and other non-cocoa trees but snakes are venomous and wild mammals making them undesirable. Relatedly farmers cited that snakes cannot serve as meat making them more undesirable. Species conserved by shade trees that are undesirable because they don't serve as meat or food was recorded 86 times in the total responses as shown in Fig. 2.

This is consistent with Cerdan *et al.*, 2012) who recorded from farmers that lack of edible fruits for animals was also mentioned as a negative characteristic of tree species in conserving biodiversity. Ruff, 2001) also found that damage caused by insects, the development of black pod disease and completion of life are the main negative aspects of shade trees in cocoa farms in Ghana. Physical damage to cocoa (mentioned by only 33% of farmers) and attracting rodents (24%) was also identified by farmers in Smith Dumont *et al.* (2014) in Ivory Coast as the most drawbacks of shade trees.

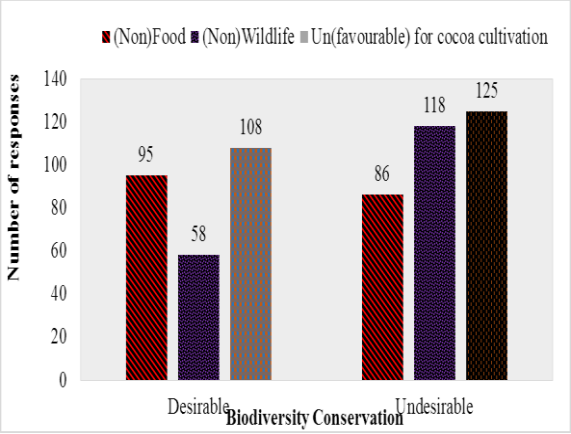

Fig. 2. Classification of biodiversity conserved in cocoa farms according to farmers knowledge.

Examples of shade trees and farmers knowledge of species they conserve

Both female and male largely perceived shade trees as valuable for conserving biodiversity within cocoa landscape according to the respondents.

Some shade trees were commonly used by farmers in narrating how shade trees conserve biodiversity in cocoa farms. Common shade trees mentioned by the study participants included *Milicia excelsa* (Odum), *Persea Americana* (Avocado), *Pycnanthus angolensis* (Otie), *Mangifera indica* (Mango), *Musa paradisiaca* (Plantain) among others. Fifty-five (55) of the study participants (84.6%) identified *Milicia excelsa* (Odum) to conserve species such as *Oecophylla smaragdina* (Nhowia), *Pycnonotus barbatus* (Akatipire) and *Tockus fasciatus* (Akyenkyina).

Another 79.8% narrated that *Persea americana* (Avocado) conserves species such as *Oecophylla smaragdina* (Nhowia) and *Sciurus carolinensis* (Squirrels). *Pycnanthus angolensis* (Otie) was observed by respondents to be conserving species such as *Sciurus carolinensis* (Squirrels) and ants representing 84.9%.

Mangifera indica (Mango) was also identified by 54 farmers (82.4%) that it helps to conserve birds *Pycnonotus barbatus* (Akatipre), *Tockus fasciatus* (Akyenkyina). *Musa paradisiaca* (Plantain) helps to conserve species such as ants *Lasius niger* (Kakape), *Theraphosidae* spp (Kyemfuo) and *Opheodrys vernalis* (Green snakes) according to 91.3% of the study participants. Finally, 81.7% noted that *Spathodea companulata* (Akuakua-ninsuo) produce water drippings and thereby regulate humidity and temperature. Furthermore, *Spathodea companulata* (Akuakua-ninsuo) was observed by farmers to help in conserving species such as *Sciurus carolinensis* (Squirrels), and ants. Another 32.3% however observed that *Terminalia superba* (Ofram) conserves water bodies by keeping river banks cool. Table 2 shows common shade trees identified by farmers and species they help conserve as well as the corresponding frequencies and percentages.

Table 2. Examples of shade trees and farmers knowledge of species they conserve.

Shade trees	Species conserved	Frequency	Percentage (%)
Milicia excelsa (Odum)	▪ *Oecophylla smaragdina* (Nhowia) ▪ *Pycnonotus barbatus* (Akatipire) ▪ *Tockus fasciatus* (Akyenkyina)	55	84.6
Terminalia superba (Ofram)	▪ *Lumbricus terrestris* (Earthworm)	58	89.2
Persea americana (Avocado)	▪ *Oecophylla smaragdina* (Nhowia) ▪ *Sciurus carolinensis* (Squirrels)	52	79.8
Pycnanthus angolensis (Otie)	▪ *Sciurus carolinensis* (Squirrels), *Pycnonotus barbatus* (Akatipire)	55	84.9
Mangifera indica (Mango)	▪ *Pycnonotus barbatus* (Akatipire) ▪ *Tockus fasciatus* (Akyenkyina)	54	82.4
Musa paradisiaca (Plantain)	▪ *Pycnonotus barbatus* (Akatipire) ▪ (Ants) (kakape) ▪ *Theraphosidae* spp (Kyemfuo) ▪ *Opheodrys vernalis* (Green snakes)	59	91.3
Spathodea companulata (Akuakua-ninsuo)	▪ *Sciurus carolinensis* (Squirrels) ▪ *Pycnonotus barbatus* (Akatipire), ▪ *Formicidae* (Ants)	53	81.7

Conclusions and recommendations

Findings from this study showed that farmers are knowledgeable about how shade trees conserve biodiversity in cocoa farms. From this depth of knowledge, how shade trees conserve biodiversity could be trees classified into four (4) groups namely food provision, habitat and safety, temperature and humidity control and soil protection. Provision of habitat and safety was most frequently mentioned by farmers followed by provision of food which turn was followed by knowledge on temperature and humidity control.

Moreover, from farmers' knowledge, species conserved by shade trees in cocoa farms are either desirable or undesirable by cocoa farmers. While it may be intuitively prudent to promote the conservation of all types of insect and small mammal species in cocoa landscape by shade trees, certain species may be undesirable for cocoa farmers.

Again, although such insects and small mammals may provide some ecosystem services in the cocoa farm, such insects may be undesirable for farmers. For example farmers do not desire snakes even though it is conserved by green leafs of *Musa paradisiaca* (Plantain) which is rather desirable non-cocoa tree.

It is recommended that to succeed in promoting cultivation of more plant and plant species in cocoa farms, it is recommended that education on benefits of plants in cocoa farms should be based on farmers' local knowledge of how shade trees conserve biodiversity. In other words trainings by governmental and nongovernmental on shade trees in cocoa farms should start from farmers expressed existing knowledge of benefits or functions of shade trees in cocoa farms.

It is further recommended that when promoting non-cocoa tree cultivation in cocoa farms, efforts should not only be focused on trees that improve the cocoa tree but those that improve biodiversity conservation by adopting farmers knowledge on the various plant species and the related biodiversity that they conserve as revealed by farmers' knowledge in this study. Thus it is recommended that NGOs and Ghana's Cocoa Board should not only focused on non-cocoa trees that are compatible or incompatible; desirable or undesirable for cocoa, but also focused on those that conserve biodiversity because farmers are not only knowledgeable in how shade trees conserve biodiversity but also desirable and undesirable species conserved by shade trees.

Efforts by nongovernmental and governmental organizations should focused on promoting a balance in the abundance of desirable and undesirable biodiversity conserved by shade trees in cocoa farms. For example snakes are wild undesirable specie while birds or squirrels are desirably edible mammals conserved by shade trees in cocoa farms according to farms knowledge. While it is prudent to conserved both desirable and undesirable species for effective ecosystem functions in cocoa farms, it is recommended that models or efforts should be developed by NGOs that promote or project how to maintain a balance in the abundance of species conserved by shade trees in cocoa farms.

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References

Anglaaere LCN, Cobbina J, Sinclair FL, McDonald MA. 2011. The effect of land use systems on tree diversity: Farmer preference and species composition of cocoa-based agro ecosystems in Ghana. Agroforestry Systems **81,** 249-265.

Anim-Kwapong GJ. 2003. Potential of some Neotropical *Albizia* species as shade trees when replanting cacao in Ghana. Agroforestry Systems **58(3)**, 185-193.

Annani YS. 2012. Farmers Perception about the Integration and Management of Shade Trees in Cocoa Farm (*Theobroma cacao* L.). BSc. Thesis. Kwame Nkrumah University of Science of Technology, Faculty of renewable natural resources, department of agroforestry, Kumasi, Ghana. pp. 17-30.

Asare R, David S. 2011. Good agricultural practices for sustainable cocoa production: a guide for farmer training. Manual on planting, replanting and tree diversification in cocoa systems, Sustainable tree crops programme, International Institute of Tropical Agriculture, Accra, Ghana. July 2011 version.

Asare R. 2005. Cocoa agroforests in West Africa: A look at activities on preferred trees in the farming systems, Danish Centre for Forest, Landscape and Planning (KVL): 77

Bisseleua DHB, Missoup AD, Vidal S. 2009. Biodiversity conservation, ecosystem functioning, and economic incentives under cocoa agroforestry intensification. Conservation Biology **23(5),** 1176-1184

Braun V, Clarke V. 2006. Using thematic analysis in psychology. Qual Res Psychol **3(2),** 77-101

Cerdán CR, Rebolledo MC, Soto G, Rapidel B, Sinclair FL. 2012. Local knowledge of impacts of tree cover on ecosystem services in smallholder coffee production systems **110,** 119-130. https://doi.org/ 10.1016/j.agsy.2012.03.014

Ghana Statistical Services GSS. 2014. Population & Housing Census District Analytical Report 2010: Bia West District. Accra, Ghana.

Gockowski J, Tchatat M, Dondjang JP, Hietet G, Fouda T. 2010. An empirical analysis of the biodiversity and economic returns to cocoa agroforests in Southern Cameroon. Journal of Sustainable Forestry **29(6-8),** 638-670. http:// dx.doi.org/10.1080/10549811003739486

Graefe S, Meyer-Sand LF, Chauvette K, Abdulai I, Jassogne L, Vaast, P, Asare R. 2017. Evaluating farmers' knowledge of shade trees in different cocoa agro-ecological zones in Ghana. Human ecology **45(3),** 321-332.

Greenberg R, Bichier P, Cruz Angón A. 2000. The conservation value for birds of cacao plantations with diverse planted shade in Tabasco, Mexico. Animal Conservation, vol **3,** 105-112.

Hainmuller J, Hiscox M, Tampe M. 2011. Sustainable development for cocoa farmers in Ghana. Baseline survey: Preliminary report- Sustainable development for cocoa farmers in Ghana. MIT and Harvard University, Cambridge, MA.

Leakey RRB. 2001. Win:Win landuse strategies for Africa: Building on experience elsewhere and capitalizing on the value of indigenous tree products, International Forestry Review **3,** 1-10.

Osei-Bonsu K, Ameyaw Oduro C, Tetteh JP. 2003. Traditional cocoa agroforestry: Species encountered in the cocoa ecosystem of a typical cocoa growing district in Ghana. 14th international cocoa research conference, Accra, Ghana. 13–18th October 2003.

Rice RA, Greenberg R. 2000. Cacao cultivation and the conservation of biological diversity. AMBIO: A Journal of the Human Environment **29(3),** 167-173.

Ruf F. 2001. Tree crops as deforestation and reforestation agents: the case of cocoa in Cote d'Ivoire and Sulawesi. In: Anglesen A, Kaimowitz D (Eds) Agricultural technologies and tropical deforestation. CABI Publishing, Oxon pp 291-315.

Schroth G, Gustavo AB, Harvey CA, Gascon C, Vasconcelos HL, Izac AMN. 2004. Agroforestry and biodiversity conservation in tropical landscapes. Island Press, Washington DC p 523.

Wireko P. 2011. Farmers' perception of agroforestry adoption in the Asunafo South District in the Brong Ahafo Region of Ghana. A thesis submitted to the school of graduate studies, Kwame Nkrumah University of Science and Technology, Kumasi in the partial fulfilment of the requirements for the award of Master of Science degree in agroforestry management practices. A case study in the North China Plain. Journal of Environmental Management **79,** 409-419.

Zapfack L, Engwald S, Sonké B, Achoundong G, Madong, BA. 2002. The impact of land use conversion on plant biodiversity in the forest zone of Cameroon. Biodiversity and Conservation **11(11),** 2047-2061.

Appendix: Exhibits from Transect walk to confirm farmer narratives.

Exhibit 1. Hole in shade tree serving as hiding or habitat for other species.